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Rezach et al.

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- (54) **INSTRUMENT FOR COMPRESSION OR DISTRACTION**
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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 508 days.

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Assistant Examiner—Elana B Fisher

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(65) **Prior Publication Data**

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- (51) **Int. Cl.**
A61B 17/60 (2006.01)
- (52) **U.S. Cl.** **606/90; 606/57**
- (58) **Field of Classification Search** 60/61, 60/86, 90; 606/57, 104, 61, 86, 90
See application file for complete search history.

(57) **ABSTRACT**

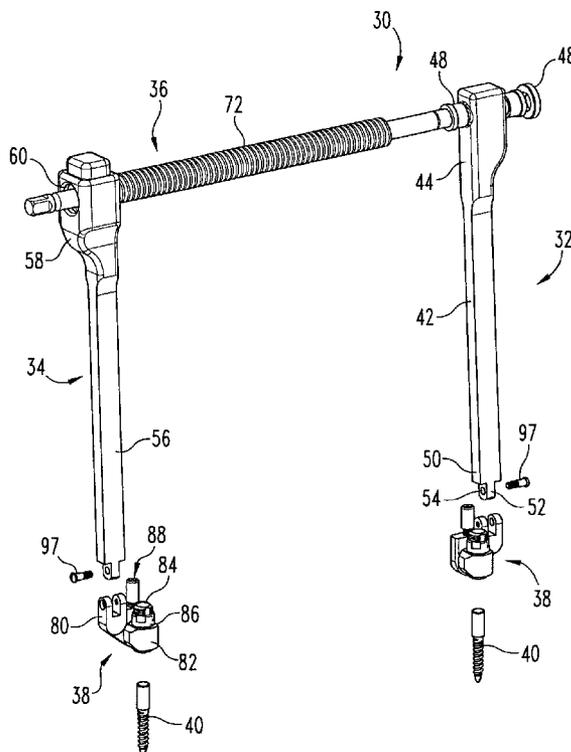
An apparatus for use in orthopedic distraction or compression is disclosed. In the illustrated embodiments, two arms are provided that are connected by a rod or bar with a mechanism that enables the arms to be brought toward or away from each other. At the end of each arm, an assembly for connecting to a bone implant is provided. The assemblies are pivotable with respect to the arms, and allow some rotational motion between parts of the assembly so as to accommodate different positions of the bone implants. Once the assemblies are appropriately positioned, connected and locked to the bone implants, the mechanism can be operated to move the arms together in compression or apart in distraction.

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35 Claims, 15 Drawing Sheets



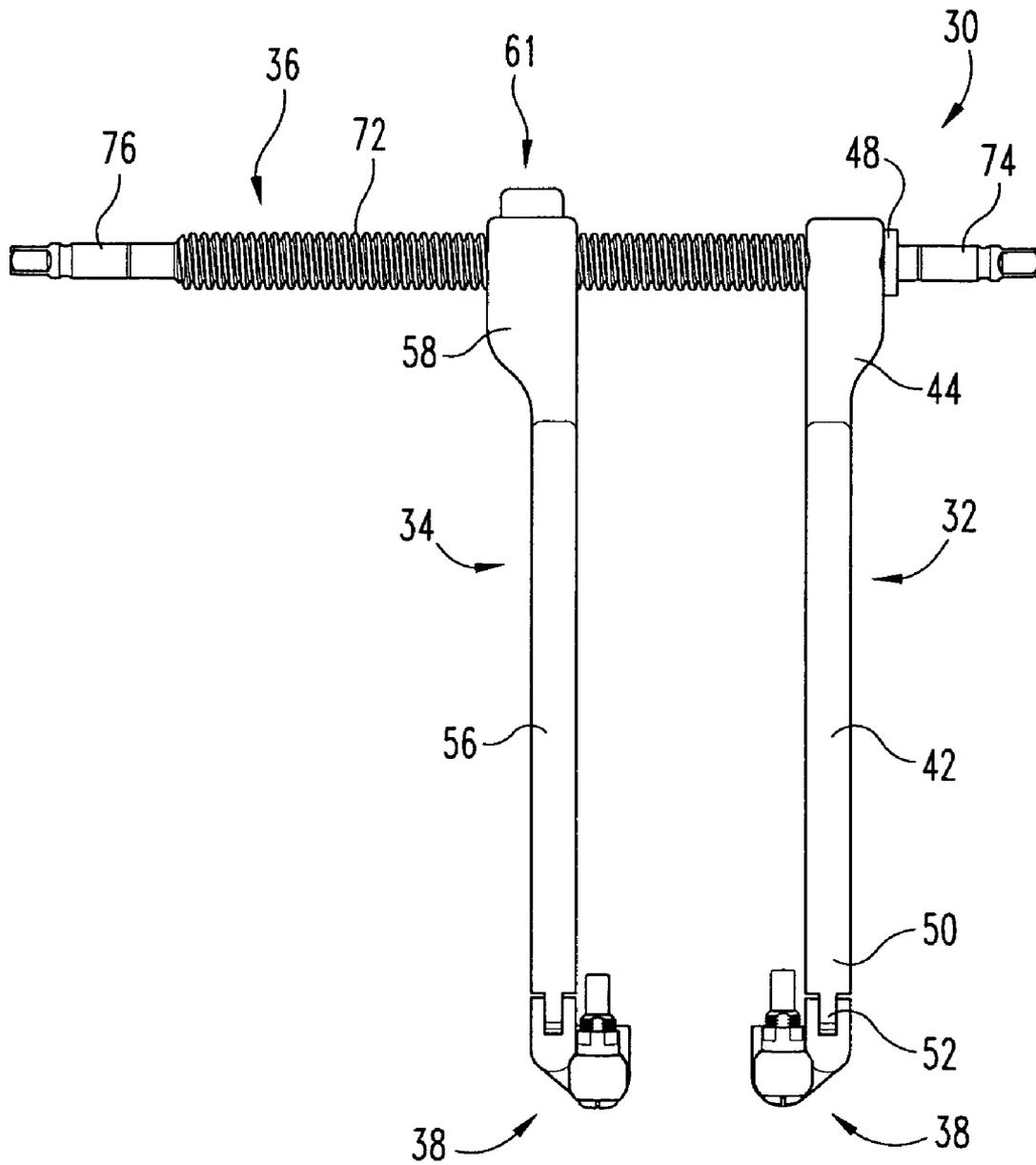


Fig. 1

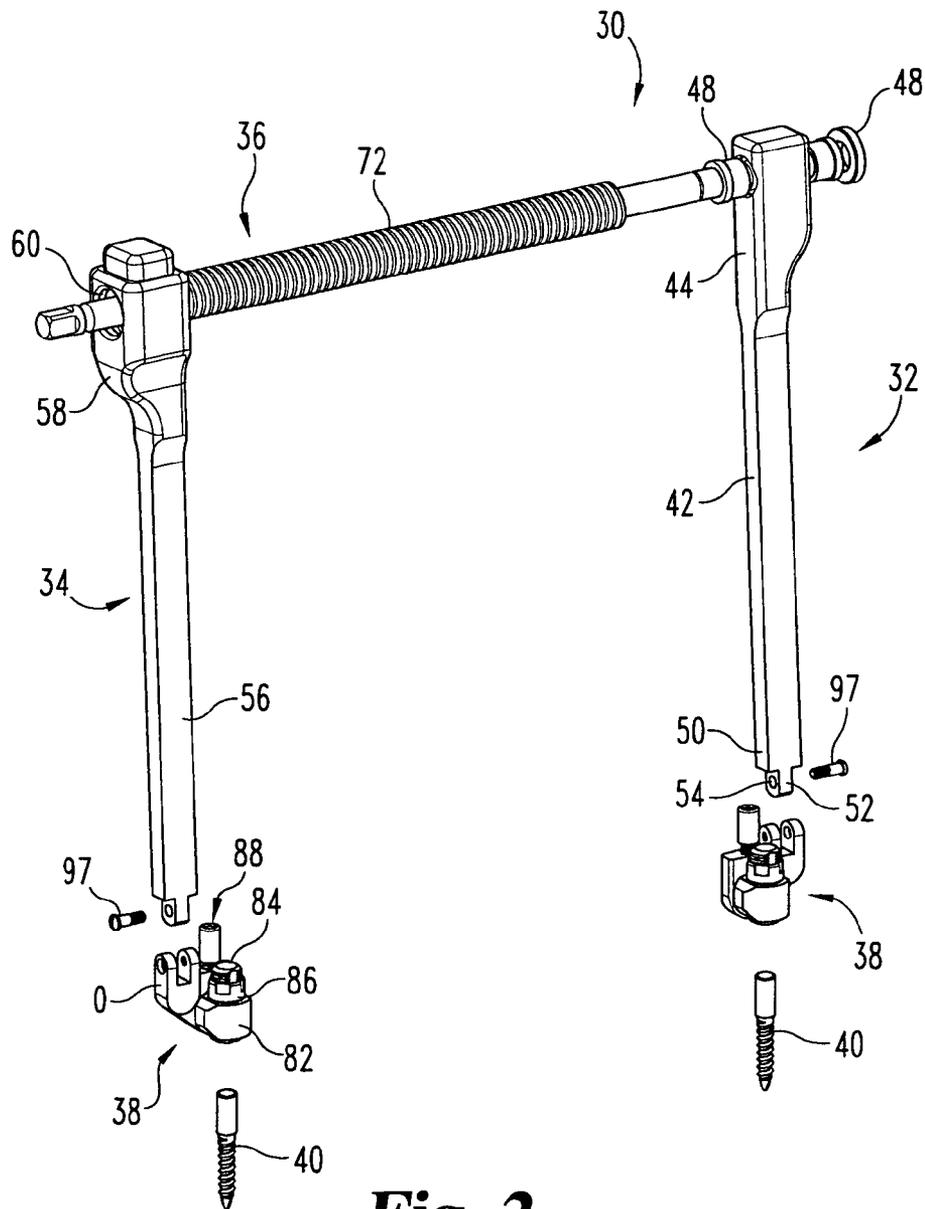


Fig. 2

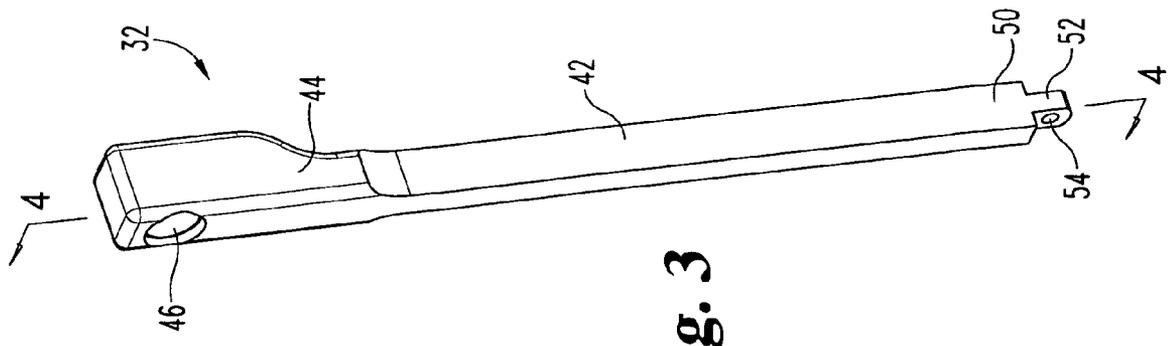


Fig. 3

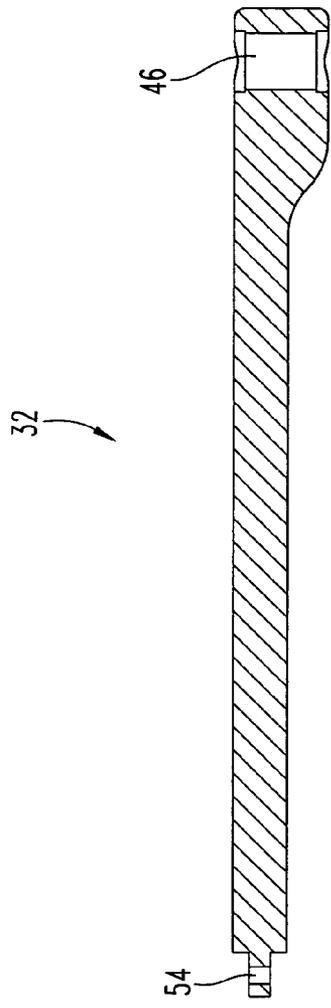


Fig. 4

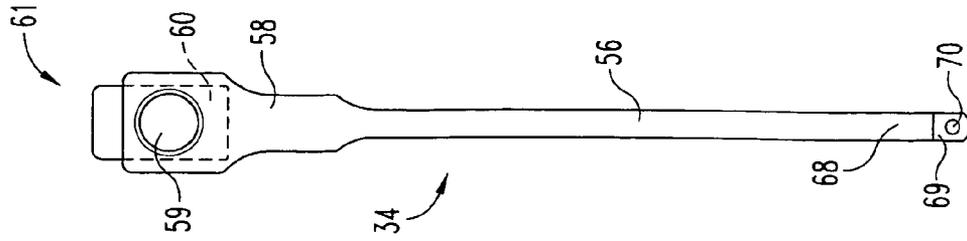


Fig. 5

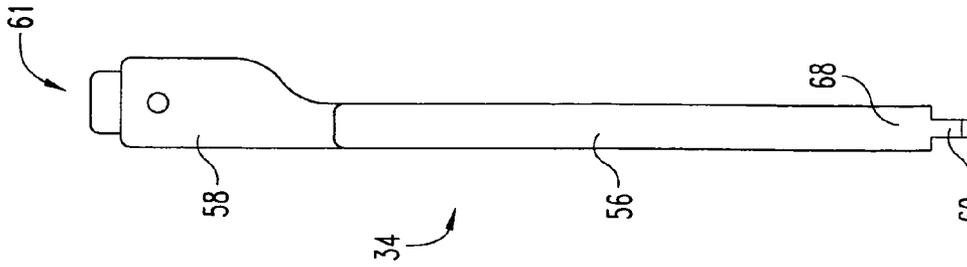


Fig. 6

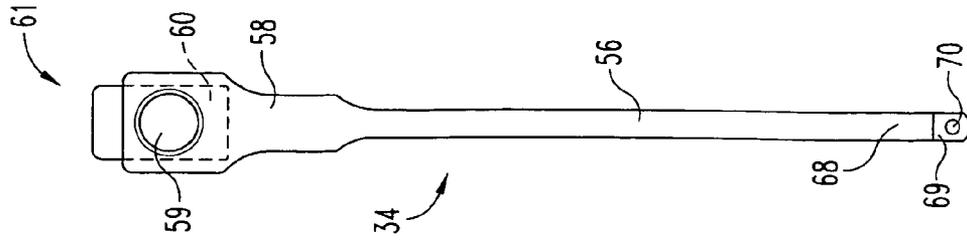


Fig. 7

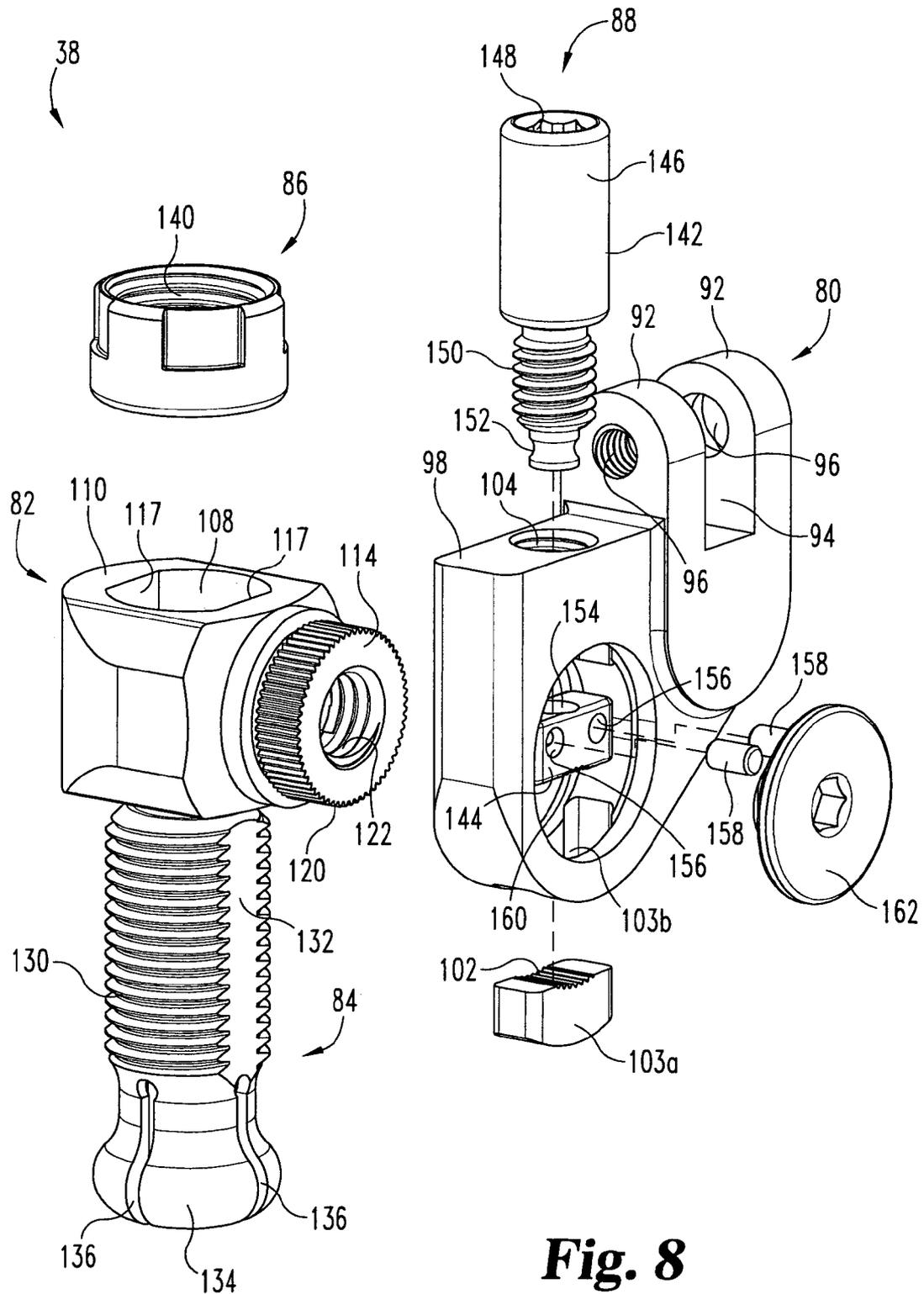


Fig. 8

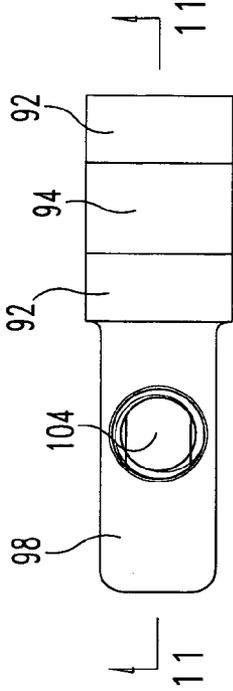


Fig. 10

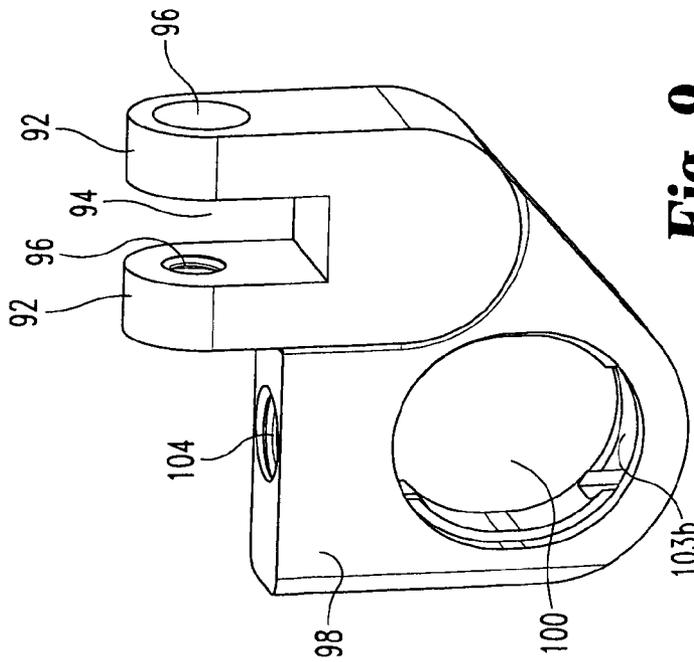


Fig. 9

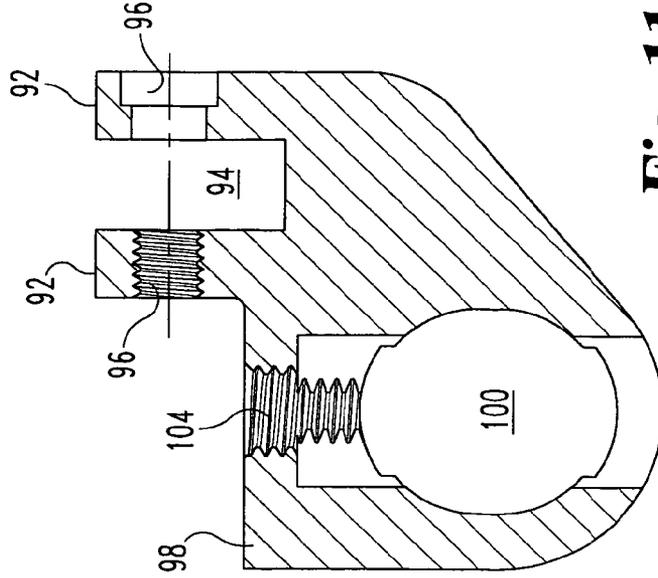


Fig. 11

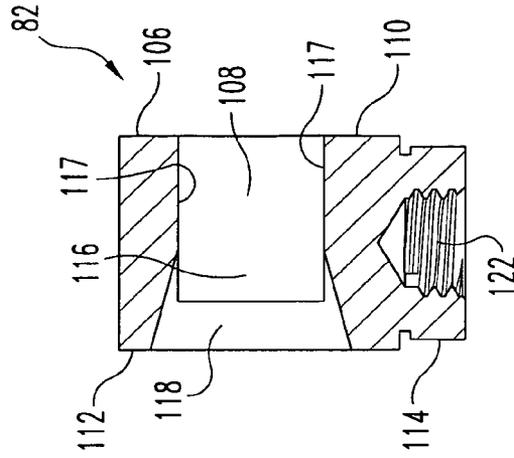


Fig. 14

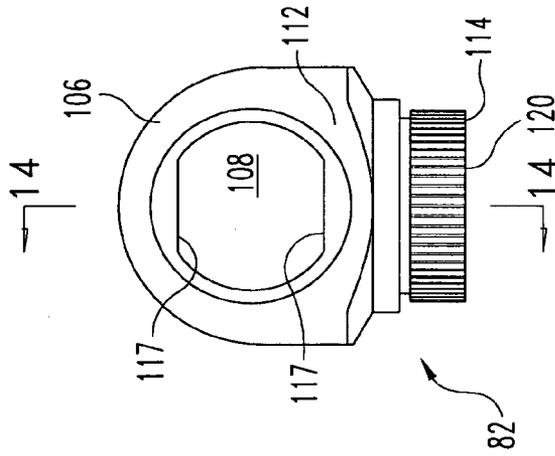


Fig. 13

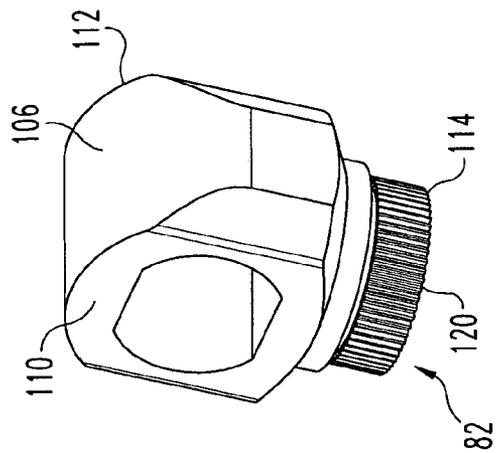


Fig. 12

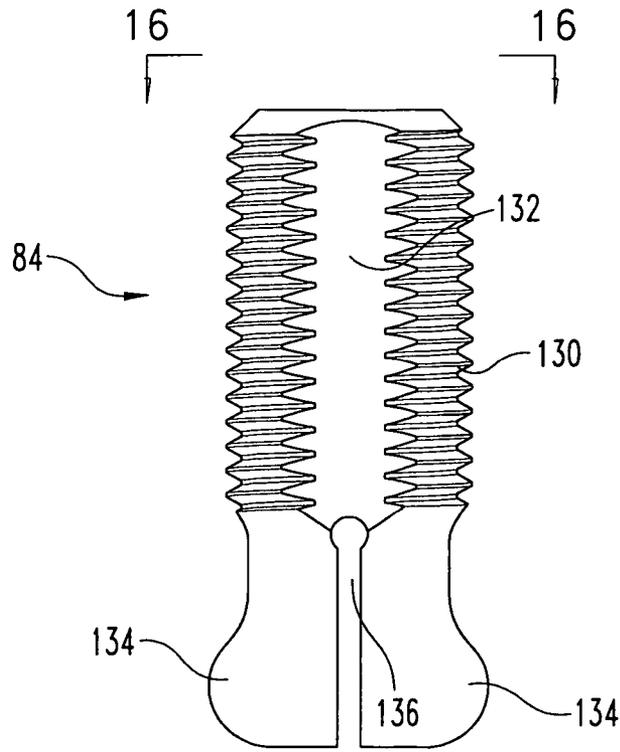


Fig. 15

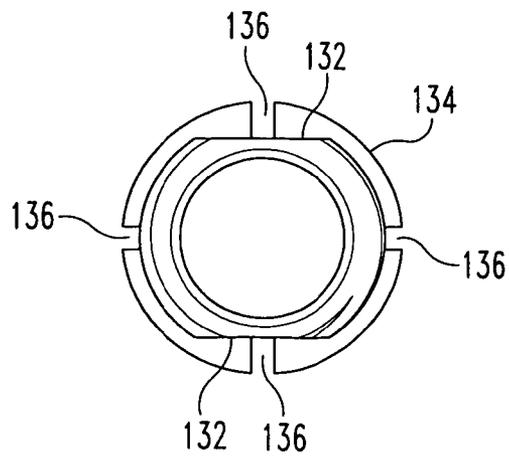


Fig. 16

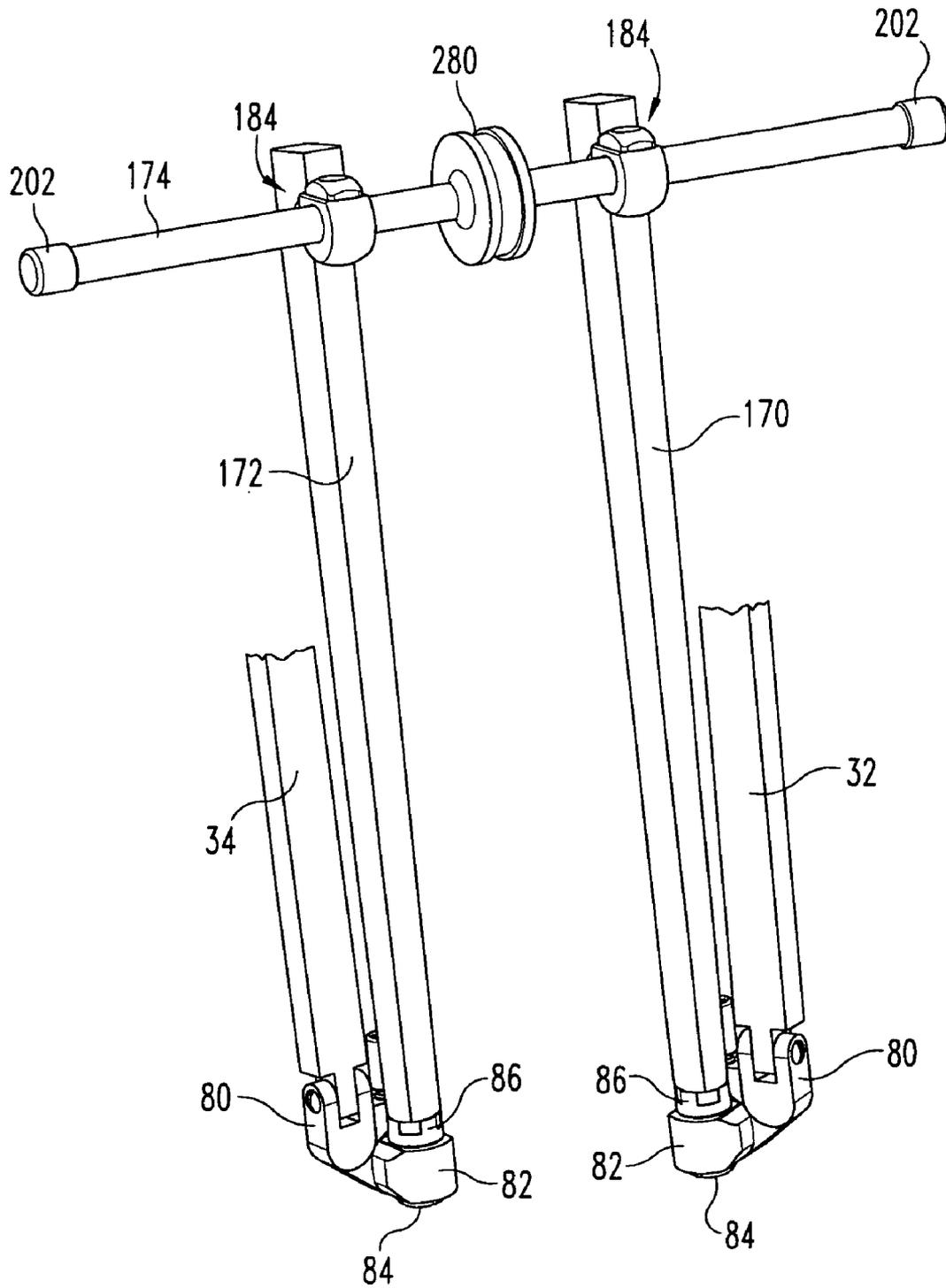


Fig. 17

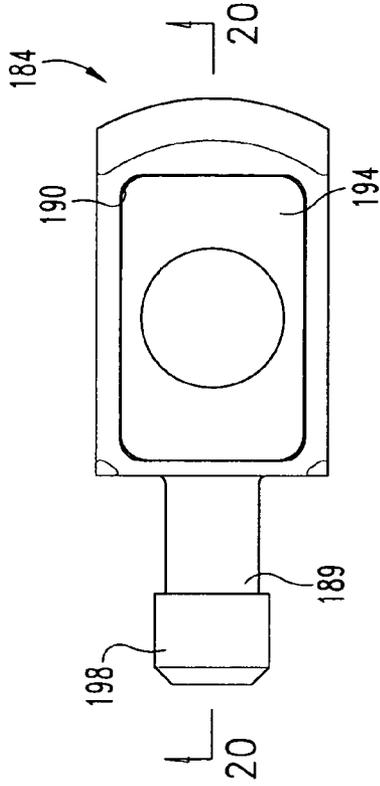


Fig. 19

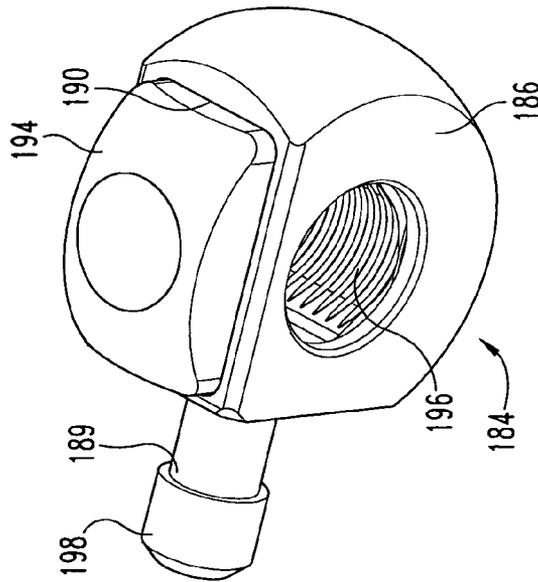


Fig. 18

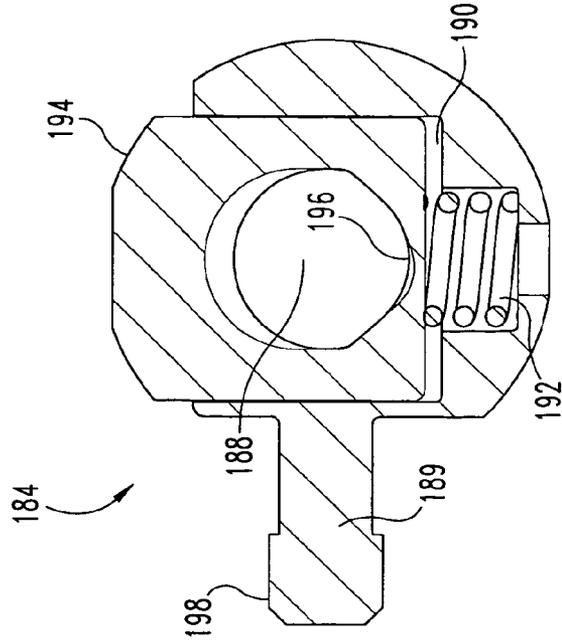


Fig. 20

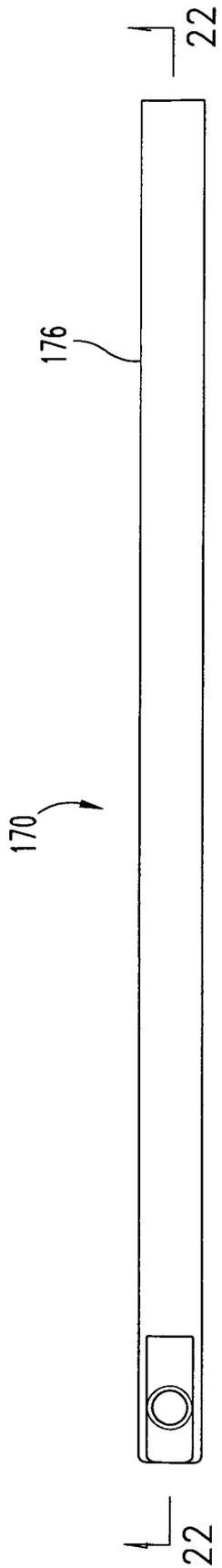


Fig. 21

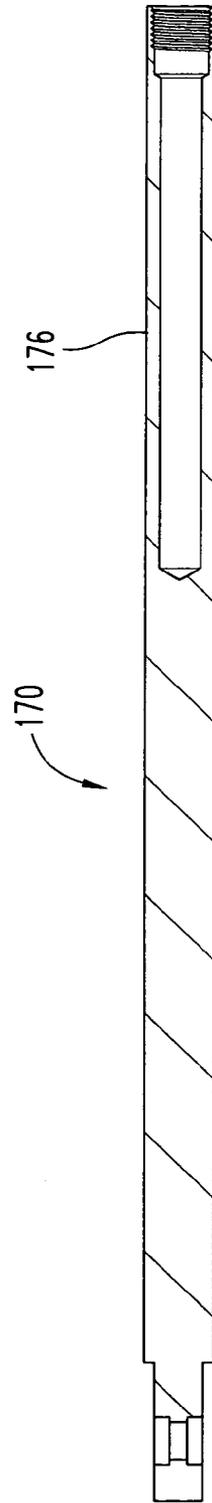


Fig. 22

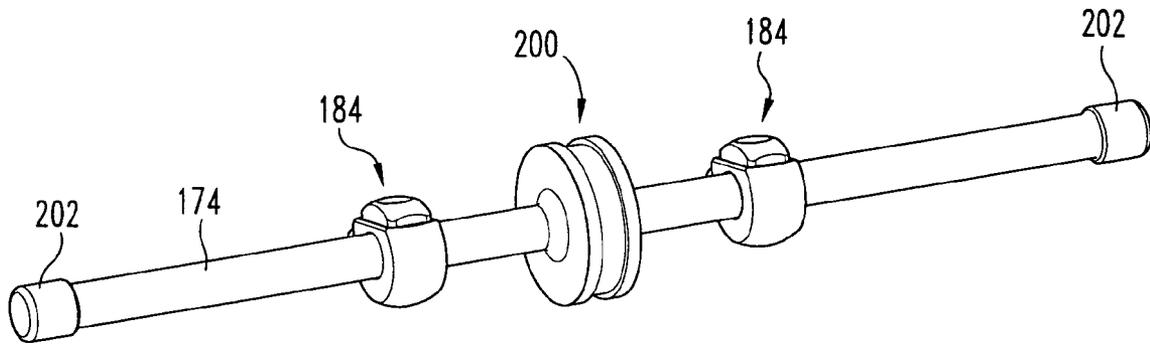


Fig. 23

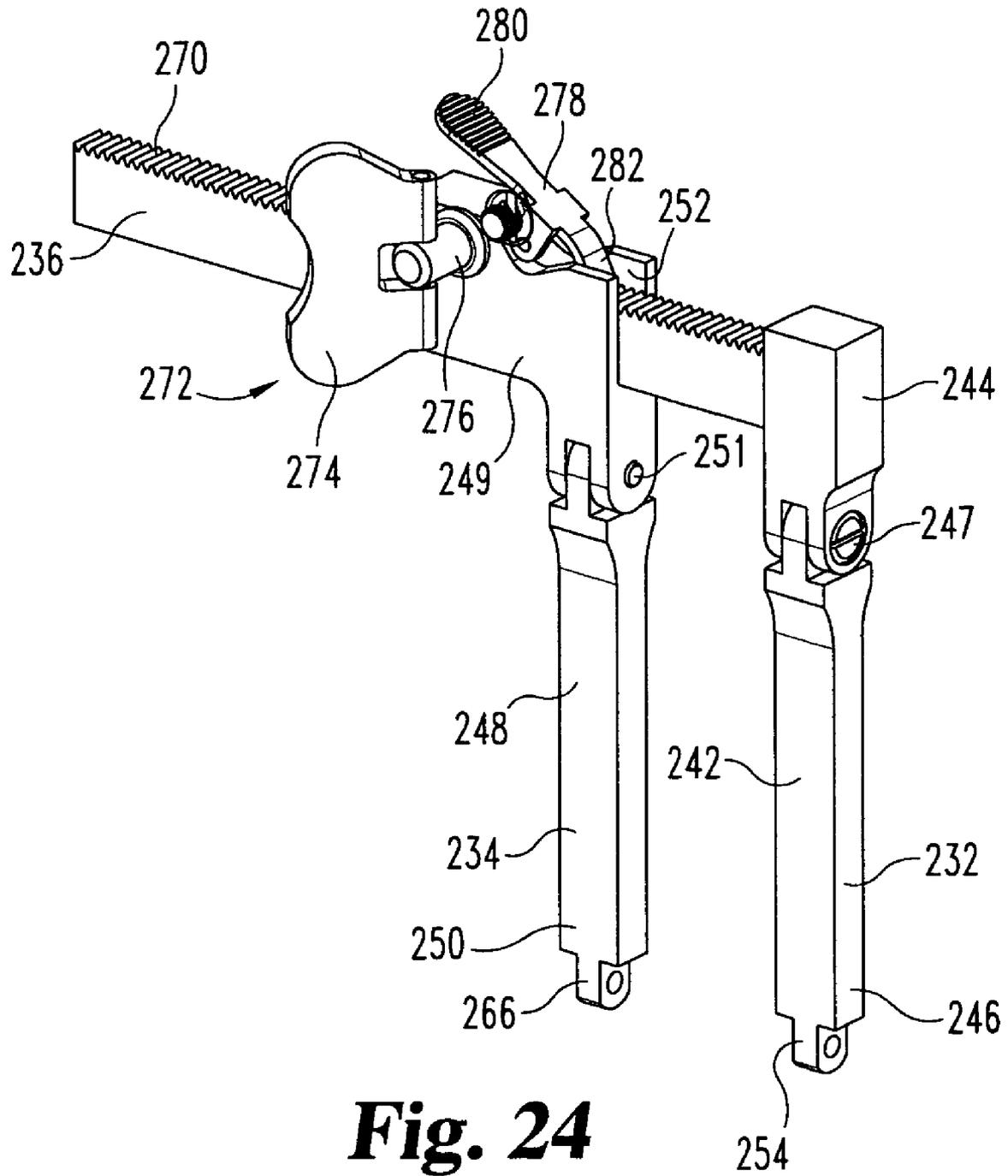


Fig. 24

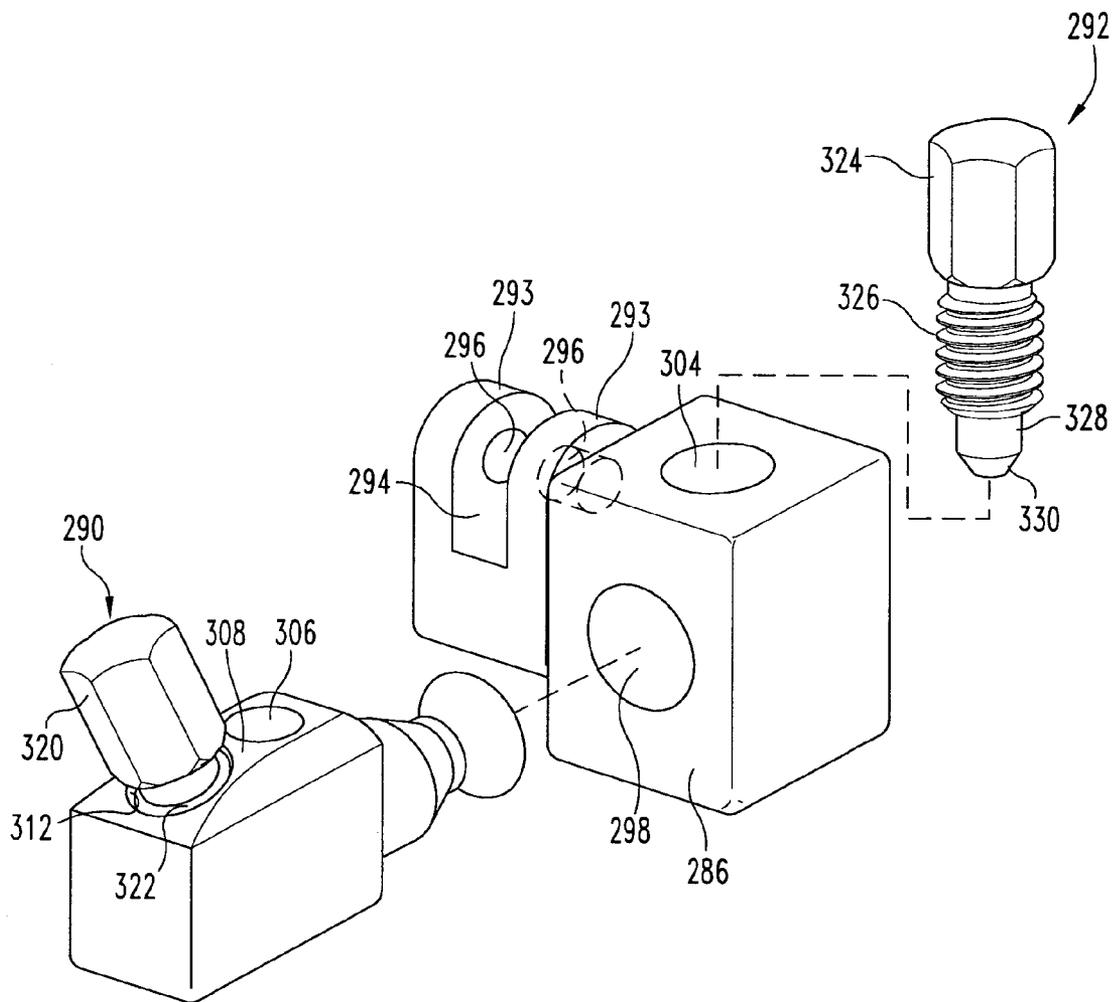


Fig. 25

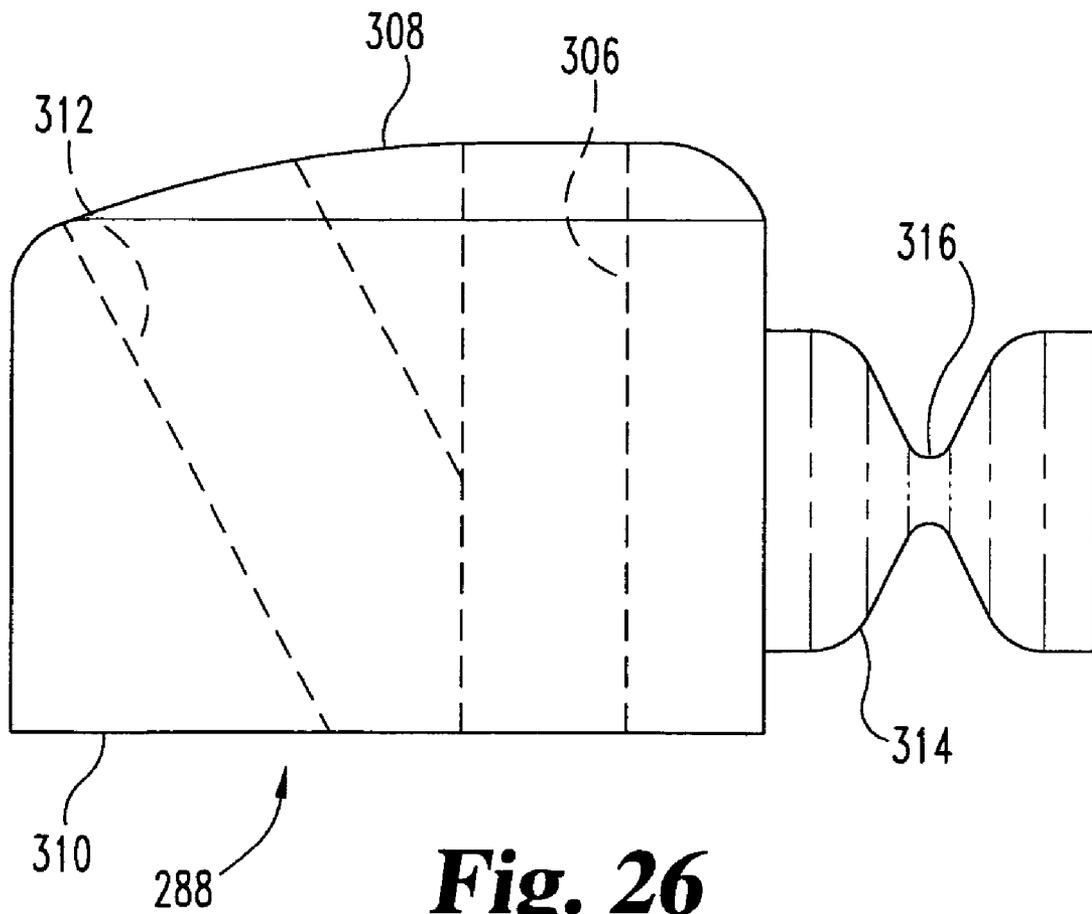


Fig. 26

1

INSTRUMENT FOR COMPRESSION OR DISTRACTION

The present disclosure relates to instrumentation useful in orthopedic surgery, and in particular to instrumentation useful in compressing (moving together) or distracting (moving apart) tissues such as bones (e.g. vertebrae) or bone fragments.

BACKGROUND

Several types of tools for compressing or distracting tissues such as bones or bone fragments toward healing of a trauma or correcting of an abnormality are known. Among these include instruments that use cables to pull together bones or artificial implants placed in such bones, scissor-like tools that apply leverage around a central fulcrum to move bones or implants toward or away from each other, and even the surgeon's own hands. Such manipulations or adjustments of bones are indicated for correction of a number of orthopedic conditions. For example, in the case of a scoliosis or other abnormal positioning of the spine, one or more vertebrae or vertebral segments may require compression or distraction with respect to adjacent bones to achieve a better or more normal position. In the case of a trauma, for example after an injury to a bone or adjacent tissue or removal of a cancerous or other mass, compression or distraction of tissue may be required to induce proper healing, to accommodate a therapy such as implantation of spacing or holding devices or of therapeutic material (e.g. bone morphogenic protein (BMP), allograft, autograft or other osteogenic substances, or medications), or for other reasons. Prior compression and/or distraction tools are not always useful, or may be awkward to use, in certain surgical pathologies or situations. Thus, there remains a need in the art for such instruments that provide advantages over existing tools.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of an embodiment of an instrument useful in orthopedic surgery.

FIG. 2 is a partial exploded view in perspective of the embodiment shown in FIG. 1.

FIG. 3 is a perspective view of an embodiment of an aspect of the embodiment shown in FIG. 1.

FIG. 4 is a cross-sectional view of the structure shown in FIG. 3, taken along the lines 4-4 in FIG. 3 and viewed in the direction of the arrows.

FIG. 5 is an exploded view in perspective of an embodiment of another aspect of the embodiment shown in FIG. 1.

FIG. 6 is a rear view of the structure shown in FIG. 5.

FIG. 7 is a side view of the structure shown in FIG. 5.

FIG. 8 is an exploded view in perspective of an embodiment of another aspect of the embodiment shown in FIG. 1.

FIG. 9 is a perspective view of a part of the structure shown in FIG. 8.

FIG. 10 is a top view of the structure shown in FIG. 9.

FIG. 11 is a cross-sectional view of the structure shown in FIG. 8, taken along the lines 11-11 in FIG. 9 and viewed in the direction of the arrows.

FIG. 12 is a perspective view of another part of the structure shown in FIG. 8.

FIG. 13 is a bottom view of the structure shown in FIG. 12.

FIG. 14 is a cross-sectional view of the structure shown in FIG. 12, taken along the lines 14-14 in FIG. 13 and viewed in the direction of the arrows.

2

FIG. 15 is a side view of another part of the structure shown in FIG. 8.

FIG. 16 is a top view of the structure shown in FIG. 15.

FIG. 17 is a perspective view of an embodiment of additional structure attached to the embodiment of FIG. 1, with only parts of the embodiment of FIG. 1 shown.

FIG. 18 is a perspective view of an aspect of the embodiment shown in FIG. 17.

FIG. 19 is a top view of the structure shown in FIG. 18.

FIG. 20 is a cross-sectional view of the structure shown in FIG. 18, taken along the lines 20-20 in FIG. 19 and viewed in the direction of the arrows.

FIG. 21 is a side view of another aspect of the embodiment shown in FIG. 17.

FIG. 22 is a cross-sectional view of the structure shown in FIG. 21, taken along the lines 22-22 in FIG. 21 and viewed in the direction of the arrows.

FIG. 23 is a perspective view of aspects of the embodiment shown in FIG. 17.

FIG. 24 is a perspective view of part of another embodiment of an instrument useful in orthopedic surgery.

FIG. 25 is an exploded view in perspective of an assembly connectable with the embodiments shown in FIGS. 1 and 24.

FIG. 26 is a side view of part of the structure shown in FIG. 25.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated, as would normally occur to one skilled in the art to which the invention relates.

An embodiment of an instrument 30 is shown in FIG. 1. In that embodiment, instrument 30 includes a first elongated arm 32, a second elongated arm 34, and a threaded rod 36 connected to arms 32 and 34. In a particular embodiment, arm 32 is fixed with respect to rod 36, and arm 34 is movable with respect to rod 36. In an alternative embodiment, arm 34 could be fixed with respect to rod 36, and arm 32 could be movable with respect to rod 36. At an end of arm 32 opposite from rod 36, there is an assembly 38 for connecting to an orthopedic implant 40. Such implants may include bone hooks or screws, and in one embodiment may be a Schanz-type screw with a relatively smooth, cylindrical upper portion. Other types of implants could also be used with the illustrated embodiment of instrument 30. A similar assembly 38 is positioned at the end of arm 34 opposite rod 36.

Arm 32 has a medial portion 42 that in the depicted embodiment has a substantially square or rectangular cross-section. Medial portion 42 may also be substantially cylindrical or of other appropriate shape in cross-section. At a first end 44 of arm 32, a hole 46 is provided to accommodate rod 36. Hole 46 is substantially smooth in the illustrated embodiment. Bushings or washers 48 are provided that fit around rod 36 and may extend at least partially into hole 46 to allow rod 36 to rotate with respect to arm 32, while limiting or inhibiting substantial movement of arm 32 along rod 36. Such bushings, if provided, may be tightly fitted, welded or otherwise attached to rod 36. Arm 32 may move between bushings 48 if the distance between bushings 48 is greater than the width of

end 44. Other embodiments may include other mechanisms, such as pins or balls provided through end 44 that at least partially intersect hole 46, which are designed to engage rod 36 or grooves or indentations in it. End 44, in the illustrated embodiment, has a somewhat larger cross-section than medial portion 42. A second end 50 of arm 32 includes a tongue 52 with a hole 54 for accommodating an axle.

Arm 34 is substantially similar, in the illustrated embodiment, to arm 32. A medial portion 56 is provided that is substantially the same as or identical to medial portion 42 of arm 32. A first end portion 58 has a hole 59 and an aperture 60 through its top, and may be of somewhat larger cross-section than medial portion 56. A release mechanism 61 is provided at end 58. The illustrated embodiment of release mechanism 61 includes a button 62 and a spring 63. Button 62 includes an opening 64 with a threaded bottom 65, which is compatible with threads on rod 36, and a side slot 66. Spring 63 fits within end 58, and button 62 sits atop spring 63 so that rod 36 can extend through hole 59 and opening 64, and so that the top of button 62 is above the top of end 58. A pin 67 fits through end 58 and into slot 66 to keep spring 63 from ejecting button 62 from end 58. Pressing button 62 allows a threaded portion of rod 36 to be pulled through hole 59 without turning rod 36. Releasing button 62 when a threaded portion of rod 36 is in opening 64 results in the threaded engagement of bottom 65 of button 62 with rod 36. As with the illustrated embodiment of arm 32, arm 34 has a second end 68, with a tongue 69 having a hole 70 for an axle.

Rod 36 includes a threaded portion 72 and unthreaded end portions 74 and 76, in the illustrated embodiment. Part or all of ends 74 and/or 76 may have substantially square cross-sections, and a knob (not shown) may be integral with or fitted onto either end (e.g. end 74). Turning rod 36 in one direction moves arm 34 away from arm 32, and turning rod 36 in the other direction moves arm 34 toward arm 32. In embodiments in which one or both ends 74 and 76 have a square cross-section, rod 36 may be turned by a tool such as a nut driver or wrench with a square imprint or slot, or by a gripping tool such as a pliers. In embodiments having a knob, rod 36 may be turned by turning the knob.

One assembly 38 connects to arm 32 and another assembly 38 connects to arm 34, in the illustrated embodiment. Each assembly 38 connects to a respective implant that have each been implanted in bone tissue, for example a vertebra. For convenience, assembly 38 will be described below with reference to arm 32. It will be understood that the illustrated embodiment of assembly 38 operates with arm 34 in substantially the same way. Assembly 38 includes a connecting body 80 that connects to arm 32, an extension 82 that connects to the connecting body 80, a collet 84 that substantially surrounds a portion of an implant and fits at least partially within extension 82, a nut 86 that connects to an upper portion of collet 84, and a locking assembly 88.

Connecting body 80 in the illustrated embodiment is a relatively flat piece having a pair of prongs 92 defining a slot 94. Each of prongs 92 includes a hole 96, one of which may be threaded. Slot 94 is sized and configured to be able to mate with tongue 50 of arm 32. For example, tongue 50 may fit into slot 94 so that hole 54 through tongue 50 substantially aligns with holes 96 through prongs 92. An axle 97, which may be a partially threaded screw when one of holes 96 is threaded, is passed through holes 96 and hole 54, linking arm 32 and connecting body 80 so that they can rotate with respect to each other. A similar connection can be made between a connecting body 80 and arm 34.

Connecting body 80 also includes, in the illustrated embodiment, a side portion 98 through which a hole 100

extends. Hole 100 is generally oval-shaped in one embodiment, and is sized and configured to accommodate part of extension 82, as further discussed below. A set of splines 102 may be formed or placed along a bottom portion of hole 100, or otherwise positioned within hole 100. In a particular embodiment, splines 102 are on a block 103a that is fixed (e.g. by welding or other fixing method) in an opening 103b in the bottom of body 80. An opening 104 is provided for part of locking assembly 88, as will be further discussed below. In the illustrated embodiment, opening 104 is threaded for a set screw.

Extension 82 includes a holding portion 106 having a hole 108 from a top surface 110 to a bottom surface 112, and a leg portion 114 generally laterally offset from holding portion 106. Hole 108 has a portion 116 that is part cylindrical with flat walls 117, and a generally conical portion 118. Portions 116 and 118 could be otherwise configured, e.g. including concave or convex surfaces. Hole 108 is generally sized to accommodate collet 84 as further described below. Leg portion 114 is generally cylindrical in the illustrated embodiment, but may be oval, square, or otherwise configured in cross-section. Leg 114 has an outer surface that includes a series of splines 120 that are preferably substantially parallel to a longitudinal axis of portion 114. In one embodiment, splines 120 extend substantially around the entire diameter of leg 114, and extend along substantially the entire length of leg 114. It will be seen that only certain parts, such as a relatively upper and relatively lower part of leg 114, may include splines 120. Leg 114 may have an opening, such as threaded opening 122 in the illustrated embodiment, or may be solid or partially or completely filled.

Collet 84 includes a substantially cylindrical internal hole 124 from a top surface 126 to a bottom area 128. Externally, the illustrated embodiment of collet 84 includes a threaded portion 130 with flat portions 132 on one or more sides of collet 84. A lower portion of collet 84 includes a convex portion 134, which may be spherically convex, and a series of slots 136. The distance between flat portions 132 is slightly less than the distance between flat walls 117 in extension 82, in one embodiment. Collet 84 is inserted within hole 108 of extension 82. Hole 124 through collet 84 is sized and configured to accommodate part of an implant.

Nut 86 is provided with internal threads 140 that correspond to threaded portion 130 of collet 84. As will be further described below, nut 86 threads onto threaded portion 130 of collet 84 and against top surface 110 of extension 82, to pull collet 84 along hole 108 of extension 82.

Locking assembly 88 includes a set screw 142 and a block 144 connected to set screw 142. Set screw 142, in the illustrated embodiment, has a head portion 146 that is substantially smooth and cylindrical and includes an internal print 148 in a top portion, and a threaded portion 150 that includes a substantially circular or annular groove 152. Block 144 includes a hole 154 to accommodate the threaded portion 150 of set screw 142, and two smaller holes 156 that communicate with hole 154. Pins 158 are inserted through holes 156 so that they are at least partially in groove 152 when set screw 142 is inserted into block 144. Pins 158 may be of substantially the same diameter as holes 156 and groove 152. Splines 160 are on an underside of block 144, in one embodiment, to interact with splines 120 on leg 114. A cap 162 may be fitted into opening 122 in extension 82 to hold extension 82 and body 80 together.

Assembly 38 is assembled substantially as noted above, with collet 84 within hole 108 of extension 82, leg 114 of extension 82 inserted into hole 100 of connecting body 80, and locking assembly 88 in connecting body 80. Nut 86 may

be loosely threaded around threaded portion **130** of collet **84**, or may be initially separate and attached to collet **84** later. Separate assemblies **38** are connected to arms **32** and **34** by inserting tongues **50** and **66** into slot **94** of the respective connecting bodies **80**, and connecting them together via a screw **97** or other axle. At this point, each assembly **38** is pivotable relative to its respective arm **32** or **34**, and extension **82** is rotatable with respect to connecting body **80** around the longitudinal axis of leg **114** of extension **82**. Such rotation of extension **82** with respect to body **80** may be substantially in a sagittal plane when instrument **30** is used in spinal surgery, depending on the location and/or orientation of the implants to which instrument **30** is connected.

Use of the illustrated embodiment of instrument **30** will now be described with reference to a surgical procedure on the spine using bone screws, as an example. As noted above, instrument **30** may be used in a variety of orthopedic treatments, at other surgical sites, and/or with other types of implants.

To treat the condition or injury of the patient, the surgeon obtains access to the surgical site in a manner well known in the art, e.g. through incision and retraction of tissues. Once access to the surgical site has been obtained, e.g. via an opening such as a midline incision above the affected area, with tissue being resected laterally to the transverse process, or by other surgical procedure. The surgeon may connect one or more implants to adjacent or nearby vertebrae that require compression or distraction in order to relieve or improve their condition. For example, pilot holes in vertebrae, e.g. in pedicles, may be made, and screws may be inserted into or otherwise connected to two or more vertebrae. In one embodiment, a support member (for example, a spinal rod, with or without appropriate lateral or other connectors) may be connected to the implants, and tightened to one of the implants.

Once such implants are placed as desired by the surgeon, the surgeon can move instrument **30** into position adjacent the implants. The surgeon may first adjust the distance between arms **32** and **34** to approximately the distance between the inserted bone screws, by turning threaded rod **36** and/or by using release mechanism **61**. With arms **32** and **34** adjusted with respect to each other so that their respective assemblies **38** are adjacent the inserted implants, each implant is inserted through a respective collet **84** of adjacent assembly **38**. Each implant may be inserted into a respective collet **84** to any of a number of depths. For example, one can be inserted into a collet **84** so that a top portion extends above top surface **126** of collet **84**, while another may be inserted into another collet **84** so that the top extends half-way or slightly more through the hole **124** of that collet **84**. This ability for variable height adjustment makes it easier for the surgeon to connect instrument **30** to a pair of screws, the tops of which may not be substantially even in height. Further, extension **82** can be rotated with respect to connecting body **80** as noted above, and thus the surgeon may rotate extension **82** so that collet **84** is substantially collinear with a bone screw.

Once the screws are within their respective collets **84** as the surgeon desires, nut **86** is tightened on threaded portion **130** of collet **84**. Tightening nut **86** against upper surface **110** of extension **82** draws collet **84** along hole **108**, and forces convex surfaces **134** against the inner surface of hole **108**. Thus, tightening nut **86** forces compression of the lower portion **134** and slots **136** of collet **84**, squeezing lower portion **134** against the implant to lock collet **84** and the implant together.

To tighten extension **82** with respect to connecting body **80**, set screw **142** is tightened with respect to connecting body **80**.

Tightening set screw **142** with respect to connecting body **80** forces block **144** downward and into contact with leg **114** of extension **82**. Splines **160** on the underside of block **144** engage splines **120** on the surface of leg **114** of extension **82**. As set screw is further tightened, a lower portion of leg **114** will engage a bottom portion of hole **100** in connecting body **80**, and in the embodiment in which hole **100** includes splines **102** on a bottom part, splines **120** on leg **114** will engage such splines **102**. Thus, by tightening set screw **142**, rotation of extension **82** with respect to connecting body **80** is inhibited, and extension **82** is held with respect to connecting body **80** at a desired angular position. If implants are locked to assemblies **38** first, then rotational adjustments to the implanted vertebra(e) can be made by rotating extension **82** with respect to connecting body **80**. Locking extension **82** with respect to body **80** retains such vertebra(e) in the adjusted position.

Once the bone screws are connected to their respective assemblies **38**, compression or distraction of the bones to which the bone screws are attached can occur. The surgeon may turn rod **36** in one direction to bring arm **34** toward arm **32**, to achieve compression of the bones. Conversely, the surgeon may turn rod **36** in the other direction to move arm **34** away from arm **32**, resulting in distraction of the bones. Once distraction or compression is performed to the surgeon's satisfaction, a support member may be tightened to one or both of the implants to maintain the distracted or compressed state of the vertebrae. Instrument **30** may be removed by loosening nuts **86** on assemblies **38** and sliding collets **84** off their respective implants.

There may be provided with instrument **30** further structure to assist in angular adjustment of implants and their respective assemblies **38**. Referring generally to FIG. **17** and related figures, two leverage arms **170** and **172** are connected by a threaded rod **174**. Arms **170** and **172** are substantially identical, and therefore arm **170** will be further described below. Arm **170** may be at least partially hollow, having an opening in a lower end **176** that may be positioned over part of the associated assembly **38**. The illustrated embodiment of opening **176** is substantially cylindrical with threads compatible with threads of collet **84**. Opening **176** could be without threads, could include an internal print, for example a print sized and configured to accommodate nut **86**, or could be otherwise configured.

An upper end **178** of arm **170** in the illustrated embodiment has a thin portion **180** with a hole **182**. A grommet assembly **184** is connected to arm **170** via hole **182**. Grommet assembly **184** includes a base **186** with a hole **188**, an aperture **190** substantially transverse to hole **188**, and a leg **189**. A spring **192** is in aperture **190**, and a button **194** with a threaded hole **196** sits in aperture **190** atop spring **192**. Leg **189** may include an enlarged end **198** sized and configured to retain leg **189** in hole **182** of arm **170**. In one particular embodiment, end **198** is attached to leg **189** after leg **189** is inserted through hole **182** and is fixed to leg **189**, for example by gluing or welding. In other embodiments, end **198** can be flexible or elastically compressible, so that end **198** can be attached to or integral with leg **189**, and can be forced through hole **182** without losing the ability to retain leg **189** in hole **182**. Grommet assembly **184** can rotate with respect to arm **170** around an axis through leg **189** in the illustrated embodiment. The threads in hole **196** are compatible with threads on rod **174**.

Rod **174** may have left-hand threads on one side, and right-hand threads on the other. In that case, one grommet assembly **184** will have left-hand threads and another grommet assembly **184** will have right-hand threads. Alternatively, rod **174** could have one type of thread on a threaded portion. A knob **200** may be provided for turning rod **174**. In particular

embodiments, knob **200** may be integrally formed with rod **174**, or it may be made separately and attached to rod **174**. Rod **174** may have flat portions compatible with gripping or turning tools. One or more end pieces **202** may be attached to rod **174** to retain one or more grommet assemblies **184** on rod **174**.

In one embodiment, a grommet assembly **184** is connected to each of arms **170** and **172** before inserting rod **174** through such grommet assemblies **184**. In that case, arms **170** and **172** can be used by themselves for leverage in applying rotational force to respective collets **84**, nuts **86** and/or implants associated with them. Again referring singly to arm **170** for convenience, the illustrated embodiment of arm **170** may be connected to collet **84** by threading opening **176** of arm **170** onto threaded portion **130** of collet **84**. In other embodiments, opening **176** may fit around, and possibly relatively closely with, nut **86** or an implant. Applying force to arm **170** causes rotation of extension **82** with respect to body **80** of assembly **38**, and/or rotation of assembly **38** around axle **97** that connects body **80** and arm **32**.

If desired, rod **174** can be connected to grommet assemblies **184** attached to arms **170**, **172** by pressing buttons **194** and inserting rod **174** through holes **196** of buttons **194** and holes **188** of bases **186**. Releasing buttons **194** engages threads of buttons **194** with threads of rod **174**. In embodiments with left-hand and right-hand threads on rod **174** and grommet assemblies **184**, turning knob **200** in one direction will force grommet assemblies **184** away from each other, turning arm **170** generally clockwise and arm **172** generally counterclockwise. Turning knob **200** in the other direction will force grommet assemblies **184** toward each other, turning arm **170** generally counterclockwise and arm **172** generally clockwise. In embodiments in which one type of thread (left-hand or right-hand) is on rod **174**, turning knob **200** moves grommet assemblies **184** in the same direction, tending to move arms **170** and **172** through substantially the same angle. Knob **200** or a portion of rod **174** could be pushed or pulled so as to change the angulation of each assembly **38** by a similar or identical amount. Once the desired angles of the assembly **38** are achieved, they are tightened as indicated above to limit or inhibit further angular movement between extension **82** and connecting body **80**. Arms **170** and **172** and the connecting rod **174** can then be slipped off assemblies **38** and removed from the surgical site. Compression or distraction, if not already performed and if desired, can be performed.

In an alternative embodiment, an instrument such as instrument **30** may have arms **232** and **234** connected by a toothed rod, bar or rack **236**. Arm **232**, in the illustrated embodiment, is substantially rectangular in cross-section along a medial portion **242**, and has a first end **244** that connects to rod **236**, and a second end **246**. In the illustrated embodiment, end **244** is pivotably connected to medial portion **242** by an axle **247**, which may be a screw or other threaded element. End **244** is fixed with respect to rod **236** in a particular embodiment, as by gluing, welding, interference fitting or otherwise. Arm **234** has a medial portion **248** connected to a first end **249** and a second end **250**. The illustrated embodiment of end **249** is substantially L-shaped and is pivotably connected to medial portion **248** by an axle **251**, which could be substantially identical to axle **247**. End **249** has a channel **252** in which rod **236** sits, and is movable with respect to rod **236**, as will be further discussed below. Each of arms **232** and **234** include a tongue **254**, **266**, substantially as described above with respect to tongues **50** and **66**. Tongues **254**, **266** may connect to an assembly such as assembly **38**, or to an assembly **268** further described below, via an axle substantially as described above.

Rod **236** is shown in one embodiment as a flattened substantially rectangular solid. It will be understood that bar **236** could have any of a number of shapes, such as an elongated solid with a cross-section in the shape of a circle, square, triangle or other polygon. The illustrated embodiment of bar **236** includes a set of teeth or ridges **270** along one side, e.g. a top side.

In a specific embodiment a pinion mechanism **272** extends through a part of end **249** and into channel **252**. Pinion mechanism **272**, in one embodiment, has a handle **274** pivotably connected to a pinion **276**, which has teeth or ridges in channel **252** and in contact with teeth **270** or rod **236** in rack-and-pinion fashion, so that turning pinion mechanism **272** results in linear movement of arm **234** with respect to rod **236**. A locking pawl **278** may be included. In the illustrated embodiment, pawl **278** is a spring-loaded lever attached to end **249**, having a pushing surface **280** and a tooth-engaging end **282**. Pushing on pushing surface **280** rotates pawl **278** to disengage tooth-engaging end **282** from teeth **270** of rod **236**, permitting free movement of arm **234** with respect to rod **236**. Releasing pushing surface **280** allows tooth-engaging end **282** to resume its spring-biased position engaging teeth **270**. In embodiments having rod **236**, arms **232** and **234**, and pinion mechanism **272** and pawl **278** if included, are pre-assembled prior to surgery to form essentially a single "rack" unit for the surgeon's use.

In the illustrated embodiment, pawl **278** is oriented to allow distraction while pawl **278** is in its spring-biased state (i.e. when tooth-engaging end **282** engages teeth **270**), while limiting or preventing compression. To enable compression of vertebrae, pawl **278** may be disengaged from teeth **270** in the illustrated embodiment, or may be oriented 180 degrees opposite to what is shown in the illustrated embodiment, or may be left out altogether.

Assemblies **268** can clamp on to implants. In the illustrated embodiment, each of the assemblies **268** includes a connector body **286**, an extension **288**, a set screw **290**, and a set screw **292**. Connector body **286** is similar to connector body **80** described above, and includes two prongs **293** forming a slot **294**. Substantially collinear holes **296** are formed in each prong **293**, and accommodate a set screw or axle for connecting connector body **286** pivotably with tongue **254** of arm **232** (or tongue **266** of arm **234**). Connector body **286** further includes a hole **298** into or entirely through connector body **286**. Connector body **286** includes a threaded hole **304** for set screw **292**.

The illustrated embodiment of extension **288** includes a hole **306** from a top surface **308** to a bottom surface **310**. A threaded hole **312** is provided in extension **288** that communicates with hole **306**, and into which set screw **290** may be threaded, as described further below. In one embodiment, hole **312** is at an oblique angle with respect to hole **306**, and in other embodiments may form any of a variety of angles with respect to hole **306**. Extension **288** further includes an extending leg **314** which includes a groove **316** that in the illustrated embodiment is substantially V-shaped. The surfaces of groove **316** may be relatively smooth, or may be roughened.

Set screw **290** includes a head portion **320** and a threaded portion **322**. Threaded portion **322** may end in a conical surface that may be smooth or roughened, or may be threaded all the way to the end. As noted above, set screw **290** is threaded into hole **312** in extension **288**. Set screw **290** is threaded into extension **288** far enough so that an end portion of threaded portion **322**, or a thread of threaded portion **322**, may contact a bone implant within hole **306** of extension **288**.

An embodiment of set screw **292** has a head portion **324**, a threaded portion **326**, and a tapered tip **328**. Head **324** and threaded portion **326** are substantially the same as those of set screw **290**. Tapered tip **328** has a portion with a substantially constant diameter that is equal to or less than the root diameter of threaded portion **326**. Below that substantially constant diameter area, there is a tapered portion **330** that may be substantially conical. Set screw **292** is threaded into threaded hole **304** in connector body **286**, so that tapered tip **328** at least partially enters groove **316** of extension **288**. Tightening set screw **292** against extension **288** substantially prevents or inhibits rotation of extension **288** with respect to connecting body **286** around a longitudinal axis through leg **314** of extension **288**.

The description given above concerning surgical preparation, techniques, implantation and use of instrument **30** is equally applicable here. Implants fastened to bone tissue are inserted into holes **306** of the respective assemblies **268**, and set screw **290** is tightened so that it contacts a portion of the implant and substantially prevents or inhibits the motion of the implant with respect to extension **288**. The surgeon can rotate extension **288** with respect to connecting body **286** until he or she tightens set screw **292** sufficiently. When set screws **290** and **292** are tightened, fixing implants with respect to respective assemblies **268**, distraction or compression can occur by operating pinion mechanism **272** to move arms **232** and **234** away from or toward each other. Once a satisfactory distraction or compression has been achieved, set screws **290** for each assembly **268** may be loosened, allowing assemblies **268** and the rest of the instrument to be pulled away from the bone implants and away from the surgical site.

It will be appreciated that the parts of the embodiments shown and described may be made of biocompatible materials such as stainless steel, titanium, ceramics or hard plastics, or other known or developed biocompatible materials. Materials that can be easily sterilized and reused may be particularly useful.

In the embodiments shown and described above, bodies **80**, **280** are essentially flat, and extensions **82**, **282** are located to the side of and below prongs **92**, **292** and perpendicular to connecting bodies **80**, **280**. Other embodiments may find extension **82**, **282** directly below, directly to the side, or otherwise situated with respect to prongs **92**, **292**. Yet other embodiments may have an angle in body **80**, **280**, so that leg portions **114**, **314** of extension **82**, **282** may be at an oblique angle to a line connecting prongs **92**, **292**, or may be parallel to such a line. Body **80**, **280** may be constructed so that extension **82** is a relatively substantial distance ahead, behind, or to the side of prongs **92**, **292**. It is further noted that extension **82** has a substantially rounded shape, while extension **282** is substantially rectangular. Other shapes of extensions **82**, **282**, and alternative shapes of portions of connecting body **20**, may be used in other embodiments. Assemblies **38** and **268** may be modified by adding or replacing parts with parts from another embodiment, e.g. splines or locking set screws. Assemblies **38** and **268** may be used with a variety of arms and/or structure connecting such arms, including those disclosed above.

Rod **36**, in alternative embodiments, may be roughened or smooth rather than threaded. In such embodiments, alternative mechanisms for controlling arm **34**, including moving arm **34** relative to arm **32**, can be provided. Further, in other embodiments it may be arm **34** that is fixed and arm **32** that is movable with respect to rod **36**.

While the illustrated embodiments show two arms each with an assembly as disclosed, it will be seen that an instrument can be made and used in which one such arm (e.g. arm

32) is provided with an assembly such as assembly **38** or **268**, and a different structure or mechanism is provided for connecting to a bone, implant or other object.

The U.S. patent application Ser. No. 11/118,513, entitled ORTHOPEDIC INSTRUMENT, filed on Apr. 29, 2005, first-named inventor Bryan S. Wilcox, is incorporated herein by reference in its entirety.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

What is claimed is:

1. An apparatus for connecting to at least one orthopedic implant, comprising:

an arm;

an elongated member connected to said arm, said arm being movable along the length of said elongated member;

an assembly connected to said arm, said assembly including a connecting body connected to said arm so that said connecting body can pivot with respect to said arm, an extension connected to said connecting body so that said extension can pivot with respect to said connecting body, and a locking member connected to said connecting body and having a loosened state wherein said extension can pivot with respect to said connecting body, and a tightened state wherein said extension is locked with respect to said connecting body,

wherein said connecting body has an opening, and said extension has a hole in which an implant may be placed and locked and a leg portion that extends into said opening in said connecting body,

wherein said locking member includes a screw and a block connected to said screw, said block contacting said leg of said extension when said locking member is tightened, and

wherein said leg of said extension includes splines, said block contacting said splines when said locking member is tightened.

2. The apparatus of claim 1, wherein said opening of said connecting body has a surface with splines, and said splines of said leg of said extension engage said splines of said connecting body when said locking member is tightened.

3. The apparatus of claim 1 further comprising a collet inserted in said hole of said extension, said collet being hollow so that an implant can be inserted in said collet, said collet having one or more slots making a portion of said collet compressible around the implant.

4. The apparatus of claim 1 wherein said extension has a second hole that communicates with said implant hole for accommodating a screw, and further comprising a screw insertable into said screw hole for locking said implant with respect to said extension.

5. The apparatus of claim 1 wherein said elongated member is at least partially threaded.

6. The apparatus of claim 5 wherein said arm has a threaded portion compatible with the threads of said elongated member.

7. The apparatus of claim 6 further comprising a button and a spring connected to said arm, said button having a hole therethrough that includes said threaded portion of said arm, so that in a spring-biased state said threaded portion of said hole of said button engages said threaded portion of said

11

elongated member, and pressing said button against said spring disengages said threads.

8. The apparatus of claim 1, wherein said connecting body includes a pair of prongs defining a slot, each said prong having a hole therethrough, and said arm includes a tongue with a hole, said tongue fitting in said slot so that said hole of said tongue is substantially collinear with said holes in said prongs, and further comprising an axle extending through said holes in said prongs and said hole in said tongue, so that said connecting body can be pivoted about said axle with respect to said arm.

9. The apparatus of claim 8, wherein at least one of said holes in said prongs is at least partially threaded, and said axle is a screw.

10. The apparatus of claim 1, further comprising a second arm connected to said elongated member, said second arm being substantially immovable along said elongated member.

11. The apparatus of claim 10, further comprising an assembly connected to said second arm, said assembly including a connecting body connected to said second arm so that said connecting body can pivot with respect to said second arm, an extension connected to said connecting body so that said extension can pivot with respect to said connecting body, and a locking member connected to said connecting member and having a loosened state wherein said extension can pivot with respect to said connecting body, and a tightened state wherein said extension is locked with respect to said connecting body.

12. The apparatus of claim 11, wherein said elongated member is at least partially threaded, and said movable arm has a threaded portion compatible with the threads of said elongated member, and said second arm allows rotation of said elongated member with respect to it without substantial movement of said second arm along said elongated member.

13. The apparatus of claim 11, further comprising a rotational adjusting mechanism, said mechanism including

- a first leverage arm connected to a part of said assembly associated with said movable arm or an implant in that assembly,
- a second leverage arm connected to a part of said assembly associated with said second arm or an implant in that assembly,
- a first grommet assembly connected to said first leverage arm, said first grommet assembly having a threaded portion and a release mechanism;
- a second grommet assembly connected to said second leverage arm, said second grommet assembly having a threaded portion and a release mechanism; and
- an elongated member that is at least partially threaded inserted into said first and second grommet assemblies so that a threaded portion of said elongated member is adjacent said threaded portions of said grommet assemblies.

14. The apparatus of claim 13, further comprising a knob connected to said elongated member.

15. The apparatus of claim 14, wherein operating one of said release mechanism disengages said threaded portion of the respective grommet assembly from said elongated member.

16. The apparatus of claim 1, wherein said elongated member has teeth, and further comprising a pinion connected to said teeth and to said arm, whereby turning said pinion moves said arm with respect to said elongated member.

17. An apparatus for connecting to at least one orthopedic implant, comprising:

- an arm;

12

an elongated member connected to said arm, said arm being movable along the length of said elongated member;

an assembly connected to said arm, said assembly including a connecting body connected to said arm so that said connecting body can pivot with respect to said arm, an extension connected to said connecting body so that said extension can pivot with respect to said connecting body, and a locking member connected to said connecting body and having a loosened state wherein said extension can pivot with respect to said connecting body, and a tightened state wherein said extension is locked with respect to said connecting body; and

a collet inserted into said extension and having a threaded portion, and a nut threadable on said threaded portion of said collet, wherein tightening said nut on said collet against a surface of said extension draws said collet along said extension.

18. The apparatus of claim 17, wherein said locking member includes a screw.

19. The apparatus of claim 18, wherein said locking member includes a block connected to said screw, said block contacting said extension when said locking member is tightened.

20. The apparatus of claim 18, wherein said screw includes a tapered tip that contacts said extension when said locking member is tightened.

21. The apparatus of claim 20, wherein said extension includes a groove, and said tapered tip contacts a surface of said groove when said locking member is tightened.

22. The apparatus of claim 17, wherein said collet has one or more slots making a portion of said collet compressible around the implant.

23. The apparatus of claim 22, wherein said collet includes a compressible portion, said compressible portion of said collet has a convex exterior, and said compressible portion of said collet has an outer diameter in an uncompressed state that is at least slightly larger than an inner diameter of a hole of said extension that receives said collet.

24. The apparatus of claim 17 wherein said elongated member is at least partially threaded.

25. The apparatus of claim 24 wherein said arm has a threaded portion compatible with the threads of said elongated member.

26. The apparatus of claim 25 further comprising a button and a spring connected to said arm, said button having a hole therethrough that includes said threaded portion of said arm, so that in a spring-biased state said threaded portion of said hole of said button engages said threaded portion of said elongated member, and pressing said button against said spring disengages said threads.

27. The apparatus of claim 17, wherein said connecting body includes a pair of prongs defining a slot, each said prong having a hole therethrough, and said arm includes a tongue with a hole, said tongue fitting in said slot so that said hole of said tongue is substantially collinear with said holes in said prongs, and further comprising an axle extending through said holes in said prongs and said hole in said tongue, so that said connecting body can be pivoted about said axle with respect to said arm.

28. The apparatus of claim 27, wherein at least one of said holes in said prongs is at least partially threaded, and said axle is a screw.

29. The apparatus of claim 17, further comprising a second arm connected to said elongated member, said second arm being substantially immovable along said elongated member.

13

30. The apparatus of claim 29, further comprising an assembly connected to said second arm, said assembly including a connecting body connected to said second arm so that said connecting body can pivot with respect to said second arm, an extension connected to said connecting body so that said extension can pivot with respect to said connecting body, and a locking member connected to said connecting member and having a loosened state wherein said extension can pivot with respect to said connecting body, and a tightened state wherein said extension is locked with respect to said connecting body.

31. The apparatus of claim 30, wherein said elongated member is at least partially threaded, and said movable arm has a threaded portion compatible with the threads of said elongated member, and said second arm allows rotation of said elongated member with respect to it without substantial movement of said second arm along said elongated member.

32. The apparatus of claim 17, wherein said elongated member has teeth, and further comprising a pinion connected to said teeth and to said arm, whereby turning said pinion moves said arm with respect to said elongated member.

33. An apparatus for connecting to at least one orthopedic implant, comprising:

a first arm;

a first elongated member connected to said first arm, said first arm being movable along the length of said first elongated member;

a second arm connected to said first elongated member, said second arm being substantially immovable along said first elongated member;

wherein said first elongated member is at least partially threaded, and said first arm has a threaded portion compatible with the threads of said first elongated member, and said second arm allows rotation of said first elongated member with respect thereto without substantial movement of said second arm along said first elongated member;

a first assembly connected to said first arm, said first assembly including a first connecting body connected to said first arm so that said first connecting body can pivot with respect to said first arm, a first extension connected to said first connecting body so that said first extension can pivot with respect to said first connecting body, and a first locking member connected to said first connecting body and having a loosened state wherein said first extension can pivot with respect to said first connecting body, and a tightened state wherein said first extension is locked with respect to said first connecting body;

14

a second assembly connected to said second arm, said second assembly including a second connecting body connected to said second arm so that said second connecting body can pivot with respect to said second arm, a second extension connected to said second connecting body so that said second extension can pivot with respect to said second connecting body, and a second locking member connected to said second connecting member and having a loosened state wherein said second extension can pivot with respect to said second connecting body, and a tightened state wherein said second extension is locked with respect to said second connecting body;

a collet inserted into each of said first and second extensions and having a threaded portion, and a nut threadable on said threaded portion of said collet, wherein tightening said nut on said collet against a surface of a respective one of said extensions draws said collet along said respective one of said extensions;

a rotational adjusting mechanism, said mechanism including

a first leverage arm connected to a part of said first assembly associated with said movable first arm or an implant in said first assembly,

a second leverage arm connected to a part of said second assembly associated with said second arm or an implant in said second assembly,

a first grommet assembly connected to said first leverage arm, said first grommet assembly having a first threaded portion and a first release mechanism;

a second grommet assembly connected to said second leverage arm, said second grommet assembly having a second threaded portion and a second release mechanism; and

second elongated member that is at least partially threaded inserted into said first and second grommet assemblies so that a threaded portion of said second elongated member is adjacent said first and second threaded portions of said first and second grommet assemblies.

34. The apparatus of claim 33, further comprising a knob connected to said second elongated member.

35. The apparatus of claim 34, wherein operating one of said first and second release mechanisms disengages said threaded portion of the respective grommet assembly from said second elongated member.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 7,578,822 B2
APPLICATION NO. : 11/118641
DATED : August 25, 2009
INVENTOR(S) : Rezach et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

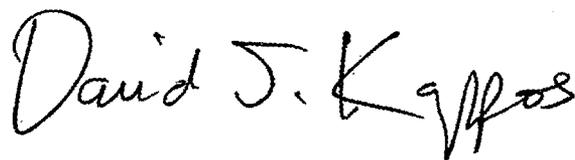
On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b)
by 991 days.

Signed and Sealed this

Seventh Day of September, 2010

A handwritten signature in black ink that reads "David J. Kappos". The signature is written in a cursive, slightly slanted style.

David J. Kappos
Director of the United States Patent and Trademark Office